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CYBERNETICS
A POWERFUL FACTOR IN SCIENTIFIC TECHNICAL PROGRESS

by V. Glushkov

- USSR -

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CYBERNETICS

A POWERFUL FACTOR IN SCIENTIFIC TECHNICAL PROGRESS

- USSR -

/Following is a translation of an article by V. Glushkov, vice-president of the Academy of Sciences Ac. Sci. UkrSSR, in the Russian-language periodical Kommunist Ukrainy (Ukrainian Communist), No.7, Kiev, 1962./

In the present period, a period of intensified struggle of the Soviet people for the creation of the technical and material base of Communism, the acceleration in all respects of the scientific and technical progress acquires extraordinarily important significance. The new program of CPSU underscores this as follows: "Progress of science and technology under the conditions of socialist system of economy permits the most effective utilization of the riches and forces of nature in the interests of the people, it permits the discovery of new forms of energy and creation of new materials, the development of methods of modification of climatic conditions, and the conquest of the cosmic space. The application of science becomes the decisive factor in the powerful growth of the productive capacities of society. The development of science and the introduction of its achievements into the nation's economy will continue to be in the future as well the object of special attention of the Party".

One of the sciences which is in the forefront of the struggle for the creation of the material and technical base of communism is cybernetics. As it grows as a direct productive force, it plays an enormous role in the technical progress influencing the productive process both directly and through the means of control, planning and accounting.

It is the practice to apply the name cybernetics to the science of general laws of transformation of information in complex regulating systems. At the same time we ascribe an extremely broad meaning to the concept of regulating system in cybernetics. Among the controlling

systems are included not only various controlling systems used in technology, but also biological regulating systems (nervous system of man and animals) and certain regulating systems existing in society (first of all, systems of control of economy).

We must immediately point out that cybernetics does not by any means deny the existence of enormous qualitative differences among all the control systems mentioned above. These differences constitute the subject of study of a number of special sciences -- technical automation, physiology of nervous system, and also a large family of social sciences. Cybernetics, then, conceives of its problem as a study of those general principles which are common to all regulating systems. And things in common among them are many.

It is apparent, first of all, that in all the regulating systems the general character of circulation of information is one and the same. The regulating system receives information from the regulated object, operates on this information in accordance with prescribed rules, and finally transmits the processed information to the regulated object. At the same time it is important to note that in cybernetics the concept of information includes not only information in its ordinary meaning (reasoned communications), but also any (not necessarily reasoned) intelligence representing various manifestations of nature (light of the sun, noise of a waterfall, etc.)

It is apparent, further, that information of any nature (visual, sonic, literal etc.) may be in the final analysis represented in a certain unified manner, for instance in the form of numbers. Still more important is the circumstance that any rules of processing of information, no matter how complex and qualitatively different, may be represented in the form of different combinations of a relatively small number of elementary rules. At the same time the indicated elementary rules will be the same regardless of the nature of the more complex rules which they aid in formulating. The latter rules may have a mathematical form(but not necessarily), or any other form, for instance, a grammatical one; they all may be equally well presented in the form of a certain combination of elementary rules.

The indicated bases of modern cybernetics establish a theoretical base for automation of various and complex processes of transformation of information to which, in the final analysis, all intellectual activity of man is reduced. Even at the present time there are automatic devices capable in principle of any transformation of information. Such devices are the modern universal electronic digital computers. The universality of these computers is assured by the fact that among their operations are included all the elementary rules of transformation

of information indicated above and also by the fact that the machine is capable of realizing any sequence of such rules.

In the presence of a universal electronic digital computer the problem of automation of a given process of transformation of information is reduced to the establishment of rules according to which the process is carried out, and to the presentation of these rules in the form of a sequence of elementary rules which the machine can follow. The latter operation, called programming, by virtue of the theoretical relationships indicated above can always be achieved, although it required, as a rule, a considerable expenditure of labor by highly skilled personnel.

It is important to note that the electronic digital computer not only liberates man from carrying out complex transformation of information, but carries out these transformations with greater precision and incomparably faster than the most qualified person. For instance, the electronic digital computer "Kiev" built in the Computer Center of the Academy of Sciences of Ukrainian SSR (now known as Institute of Cybernetics) several years ago, carries out arithmetic operations with multi-digit numbers approximately 200 thousand times faster than an experienced computer operating with a desk computing machine. At the present time we have even more rapidly operating computers.

Because of such rapidity of operation the electronic digital computer may process in a unit of time an enormous amount of information and solve such problems which previously were beyond the capabilities of man. First of all this applies to new areas of sciences and technology -- atomic physics, rocket technology, and others, whose progress to a great extent is due to electronic digital computers.

However, the utilization of electronic digital computers which constitute the substance of the technical basis of modern cybernetics acquires still greater significance for the realization of optimal projection and planning and for the automation of control of individual productive processes and of the entire economy as a whole.

As is shown by a detailed analysis, the insufficient speed of processing of information by man does not permit us to find the best variants of complex projects and processes in the majority of cases, inasmuch as the projection and planning are carried out as a rule in a somewhat limited time. Calculations show that for optimal projection and planning even in somewhat complex cases hundreds of years and even many thousands of years of work by a large staff are required; the staff in this case utilizes such means of automation for calculation as desk computers. Therefore, in a majority of cases the projects and plans

accepted for putting into practice prove to be far removed from the best (optimal) variants. However, the utilization of electronic digital computers permits us to realize optimal projection and planning and effect the economy of enormous sums of money in this manner.

As an example let us consider the planning of location of railways and highways. In the solution of this problem it is necessary to select some variants of the longitudinal profile of the road which corresponds to a greater or lesser volume of earth excavation, and also to a greater or lesser subsequent operational expenses. Increasing the volume of earth excavation, it is possible to construct a road with gentler grades and thus to reduce the operational expenses. Conversely, by increasing the operational expenditures it is possible to reduce the cost of earth work. How to select the best (optimal) variant which will yield the minimum total amount of expenditures?

When such a problem is solved at the present time by ordinary means, a large staff of experienced scientific personnel and engineers of the Central Scientific-Research Institute of Transport Construction considers many variants of construction and chooses the best of them. In this instance the planning of, say, a road one thousand kilometers long requires many months. But even this does not furnish any guarantee that the final variant of the project is truly the best one, inasmuch as it is simply impossible to review all possible variants being projected.

The Computer Center of the Academy of Sciences of Ukrainian SSR together with the Central Scientific-Research Institute of Transport Construction developed in 1961 a program for the determination of the optimal location of railways. With the aid of this program the electronic digital computer "Kiev" during only two hours of work finds the variant of the railway project which is the best one of all possible variants. The calculations have shown that the variant determined by the computer is on the average 10 percent more economical than the variant previously determined by the Institute for Transport Construction. The figures for a thousand kilometers of line show that the economy amounted to ten million rubles, which amounts exceeded the Government expenditures for the Computer Center of the Academy of Sciences of Ukrainian SSR during its entire life. And this economy was attained in only two hours of operation of the digital computer!

The cited example is adequately convincing in describing the possibilities of modern cybernetics and the effectiveness of its application.

Modern electronic computers are in essence the first sufficiently

effective devices which permit the automation not only of the area of material production, but also the area of accounting, planning and control. The absence of such means in the past resulted in the fact that the tempos of development of automation in the area of accounting, planning and control lagged seriously behind the tempos of automation in the area of material production.

In order to become convinced of this fact, it is sufficient to compare the changes which have occured in the technical equipment in these areas. During the past 25 - 30 years the technical equipment of industry, agriculture, and transport has increased sharply and this led to a marked increase in the productivity of labor (in certain areas by a factor of many tens and even of many hundreds). At the same time, the technical equipment in the sphere of accounting, planning and control of economy has changed relatively little. In this sphere we continue to use on a large scale such a "means" of mechanization as an abacus, whose age is lost in the centuries past. The replacement of abacus by desk computers which thus far has been carried out on a limited scale leads only to a relatively minor increase in the productivity of labor (categorically, but not by a factor of tens). Besides that, it must be kept in mind that these means of automation of account work cannot by any means be considered at the present time as a technical innovation. Neither can we consider as innovation the accounting-analytical machines which are supplied to the special mechanized-accounting stations which are sometimes known as "factories of mechanized accounting". The possibilities of such machines are quite limited, and this does not permit their utilization for the automation of a large proportion of even somewhat complex planning or accounting operations.

Deficiencies in the technical equipment lead to considerable increase in the administrative-control apparatus and to deterioration of its functioning. It must be noted that the advantages of the socialist system of economy assure considerably smaller proportional share of non-productive expenditures than under capitalism, including in this category the expenditures on the administrative and control personnel. Nevertheless, this apparatus even in our country is still quite considerable, and it detracts from the area of direct material production large human and financial resources.

However, the most important matter is that the constant growth of material production poses before our planning organizations more and more complex problems whose satisfactory solution cannot frequently be given today by any collective human effort if it is not accompanied by corresponding means of automation. An effort to improve the quality of the solution of these problems by a simple increase in the staff is doomed to failure.

Indeed, the amount of information which can be processed by personnel with ordinary means increases, as we know, considerably slower than the number of persons engaged in such processing of information. If all the new problems posed before our economy were to be resolved only by increasing the administrative-control apparatus, then by 1980 as indicated by preliminary figures, the entire adult population of the Soviet Union would need to be engaged in the area of regulation, planning, and accounting.

This conclusion indicates clearly that in this case we cannot follow the path of simply increasing the staff of administrative-control personnel. It is much more effective to reorganize properly the apparatus. However, even along this path, in the end, we inevitably encounter the obstacles placed by the limited informational capacities of man.

The fact of the matter is that man who is not armed with the proper technical means is capable of absorbing and processing during a working day only a limited amount of information. The volume of information which a man is capable of retaining in his memory is also limited, and this affects his capacity to process information. As a result, delays arise and sometimes simply errors arise, the solitary cause of which is informational overloading of the apparatus. First of all this applies to the system of our planning organizations, particularly in the area of material-technological supply. The basic shortcomings in the system of planning of material-technological supply were discussed in the speeches of many delegates of the XXIId Party Congress.

The only way of eliminating the indicated informational overloading and of attaining a sharp improvement in the quality of planning consists of the utilization of modern cybernetics -- electronic computers for automation of the work in the administrative-control apparatus. In this manner and only in this manner can we attain the possibility of optimal planning and regulation.

At the present time our computing centers have alreay accumulated a certain amount of experience in solving planning and economic problems by means of electronic computers. Thus, for instance, in the Computer Center of the Academy of Sciences of Ukrainian SSR there was formulated (with the assistance of electronic computer "Kiev") an optimal plan of transportating sugar beets in the southwestern region of Ukrainian SSR in 1961. This plan proved to be 8 percent more economical than the plan developed by Gosplan of Ukrainian SSR and Ukrsovnarkhoz, and its adoption resulted in a saving of 120 thousand rubles and a saving of 12 thousand freight cars.

It is possible to cite still other examples; however, the case cited above gives a sufficiently vivid concept of the possibilities which are opened by the application of modern cybernetics to the solution of economic and planning problems. In the immediate future the scale of such application must be sharply increased. The immediate problem is how to organize a unified nation wide automated system of collection and processing of information. This system will assure a markedly improved quality of planning and at the same time will reduce the number of the staff in the administrative and control apparatus. Powerful computing and information machines must make completely automatic the system of the State Bank, organs of communications, and a number of other important areas of government apparatus. Cybernetics machines each year will penetrate more and more into all spheres of life of our society.

It is important to note that only in the conditions of a socialist society, and all the more of a communist society, will it be possible to properly utilize those advantages which attend the application of cybernetic machines. In the capitalist society with its anarchy of production it is simply impossible to bring into play the proper levers of control of economy which would assure the realization of optimal plans determined by the machines. Besides that, the very concept of optimality acquires under capitalism a distorted meaning, inasmuch as from the point of view of a capitalist the "optimality" of the development of economy is taken to mean the realization of maximum profits, and as we know, such "optimality" is in direct conflict with the interests of the working people.

Along with the indicated areas of application of cybernetics we must indicate still other regions which play an important role in our society. First of all, it is the application of cybernetic machines to the control of productive processes. On the basis of modern electronis computers it is possible to create universal regulating machines which are capable of assuring optimal control of broad fields of productive processes. The first machine of this type in the Soviet Union was constructed recently by the staff of the Computer Center of Academy of Sciences of Ukrainian SSR. During 1962 several prototypes of this machine will be installed in enterprises of Ukraine. The experiments of remote control of industrial processes carried out by the Computer Center of Academy of Sciences of Ukrainian SSR during 1960 and 1961 have shown the great effectiveness of controlling machines introduced in a whole series of leading branches of industry -- metallurgical, machine building, and chemical.

At the present time the first prototype of a regulating machine designed for wide application ("UMShN") is installed in the Bessemer

department of the Dzerzhinskiy metallurgical plant. An experimental system for automatic stopping of air supply at a given carbon content in the metal and temperature control of the melt was created. In April -- May, 1962 two series of experimental melts were carried out which indicated the high effectiveness of the system. In the immediate future the introduction of this system into a three shift production schedule is planned, as well as considerable expansion of this system. The system must embrace automatic dispatching of the services in the department, and also the transportation services. Such a complex system will assure a considerable economy, will lead to an improvement in the quality of the steel being produced, and will improve the operating conditions in the department. Besides that, this first experiment of introducing a digital regulating machine of such a type in the plant will become a basis for further development and adoption of analogous systems in the industry.

In one of the shipbuilding plants of the Kherson complex there was installed a computing machine "UMShN" intended for automatic mechanization of the process of planning the technology of producing of parts of the ships' hulls and controlling the flame cutting equipment. The introduction of computing techniques in the practice of ship's hull construction will permit us to create a system of complex automation which practically eliminates completely highly skilled manual labor and which reduces considerably the time consumption and cost of constructing a ship.

Thus far the utilization of electronic computers for automation of inquiry and information service has been relatively little developed. But there is no doubt that this direction of development will have a very important future. Even now the basic principles are clear which will assure wide application of cybernetic machines to the translation of one language into another, to automatic abstracting of scientific articles, to answering inquiries with regard to patents, etc.

Broad perspectives are opened by the application of cybernetic machines not only directly in the production, accounting, planning and regulation, but also in the development of science, particularly those areas of knowledge which are intimately related to technical progress. The utilization of cybernetics has an enormous significance for the automation of complex deductive constructions and in particular for the proofs of new theorems in mathematics, construction of new physical theories, etc. The development of investigations in this direction is only now beginning, but even now a series of encouraging results is available. It may be hoped that the time is not too distant when cybernetics on a large scale will be utilized for the development of the very bases of mathematical and natural sciences, and not only as a computing tool for carrying out calculations.

There is no doubt that the application of cybernetics will aid us in finding more effective solutions of many difficult mathematical problems and also problems in physics and other natural sciences. Only along this path is it possible to assure new sharply increased tempos of development of science which at the present time is assured primarily by increasing the number of scientific workers. And the increase in the number of scientific workers is such that if it remains unchanged in the future, then in 100 - 150 years the entire population of the world would be classified as scientific workers.

Hence the colossal significance for our society which automation in the area of scientific investigations is acquiring at the present time, and which follows directly after the problem of automation of the control of the nation's economy.

The enormous role played by cybernetics in the life of society and the boundless perspectives of automation of the most diverse areas of activity related to the intellectual effort of man placed on the agenda the question of relationship between man and "intelligent" cybernetic machines. We must note immediately that cybernetics in itself cannot yield an answer to this question. Such an answer can only be given by social sciences, inasmuch as the relationship between man and machine is determined first of all by the social structure and not by the physiological features of man or technical characteristics of machine.

Cybernetics is the greatest achievement of the human mind. Buth this achievement is not everywhere utilized for man's welfare. Under capitalism the introduction of cybernetic machines leads to an increase in unemployment, and to the fact that men are thrown out of work not only in the area of physical labor but also in the area of intellectual and technical fields. This circumstance and the inability of bourgeois sociologists to explain its causes have given rise to all sorts of distortions in the question of man's future as related to the development of automation and cybernetics. All sorts of "theories" arise to the effect that in the age of cybernetics the society will have no place for the average man who will be completely replaced by machines. Certain bourgeois "theoreticians" of such type go even further. They assert that the time is near when the machines will destroy mankind and instead of human society will create a "society" of machines on earth.

It is clear that such thinking has no basis other than the conflicting positions, natural under capitalism, of technology and man and his interests. Under the conditions of communist society any

machine, including the "intelligent" cybernetic machines will be utilized only for man's welfare and not against him. No matter how perfected the machines of the future may be, historically they will always remain the creature of man's labor and genius and under the conditions of communist society will serve only the ideal of strengthening the power of man, and most completely satisfying his material and spiritual needs.

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